Fermilab

$\bar{p}$ Note #350

53 MHz Bunching in the Accumulator

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10/17/83

53 MHz Bunching in the Accumulator

Because of the desire to keep the antiprotons in the Main Ring at 8 GeV for the shortest possible time it is proposed to carry out the 53 MHz bunching in the Accumulator. The goal as before is to distribute $\sim$1.5 eVs of antiprotons among thirteen 53 MHz rf buckets with a maximum of .15 eVs in the largest bunch. This division of the h = 2 bunch provided by the unstacking system should add negligibly to the longitudinal emittance.

The final h = 84 buckets are chosen arbitrarily (but plausibly) to contain .15 eVs between of $\pm\pi/2$ in phase. The area filling factor is $\alpha_N = .4234$ for these phase limits so that the bucket area $S_B = .3542$ eVs. For 8 GeV kinetic energy and $\eta = .0236$, the required peak voltage is 76.3 kV. The h = 84 rf must be turned on at some value such that it scarcely disturbs the bunch and then raised over a few synchrotron oscillation periods to the final value. The final synchrotron tune is 1.65×10^{-3} (turns)$^{-1}$. By starting the h = 53 at 4 kV we have a bucket height $H_B = 3.4$ MeV which is safely below the bunch height of 1.5 eVs bunch which spans the phase equivalent to 13 h = 84 bunches, viz 4.4 MeV. The initial synchrotron tune number at 4 kV is $3.78\text{x}10^{-4}$. Thus, $0(10^4)$ turns are required for the capture process.

Figures 1 - 7 show a simulation of the bunching process starting with a uniform bunch of 1.5 eVs containing 2000 particles in a bucket provided by 625 V of h = 2. Figure 2 shows the partial h = 84 bunching obtained at 5000 turns and 53 MHz voltage of 7.25 kV. The h = 2 voltage is constant throughout the process. To do a reasonably smooth job it turned out that no more than 15 k turns were clearly required. The final distribution, its phase and energy projections, and the central bunch are shown in Figure 3 - 6. The central bunch has an emittance of about .15 eVs. The .15 eVs contour has been roughed in on Figure 6. The five central bunches are practically the same size and density.

If these figures are compared to those in the design report they will be found to be closely comparable. Rather few runs have been made to try refining the given parameters for superior performance, but the closeness of these results to those for the main ring which were carefully checked out shows that they are roughly optimum.

Figure 1

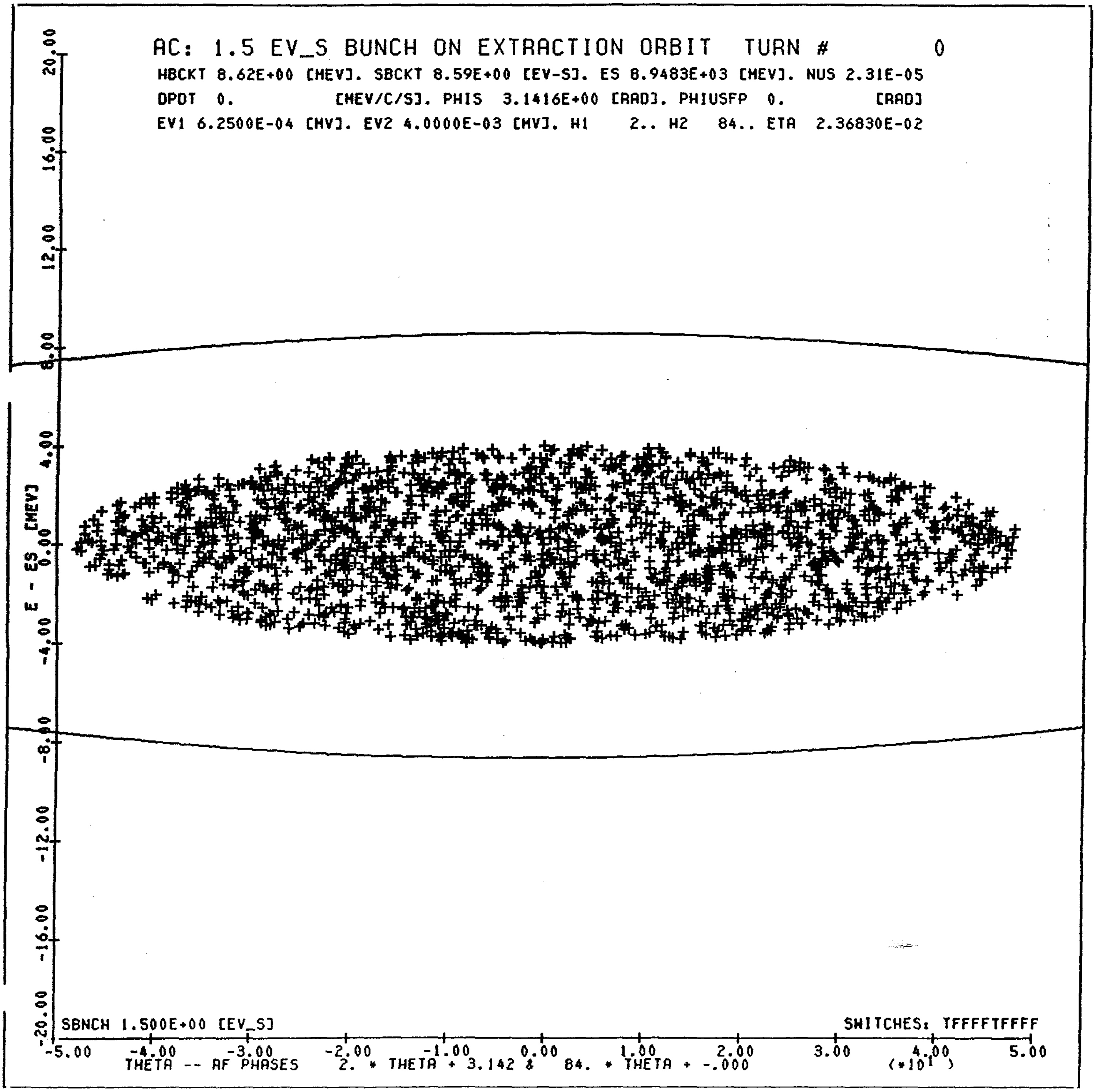

AC: 1.5 EV_S BUNCH ON EXTRACTION ORBIT TURN # 0
HBCKT 8.62E+00 [MEV]. SBCKT 8.59E+00 [EV-S]. ES 8.9483E+03 [MEV]. NUS 2.31E-05
DPDT 0. [MEV/C/S]. PHIS 3.1416E+00 [RAD]. PHIUSFP 0. [RAD]
EV1 6.2500E-04 [MV]. EV2 4.0000E-03 [MV]. H1 2.. H2 84.. ETA 2.36830E-02
E - ES [MEV]
20.00
16.00
12.00
8.00
4.00
0.00
-4.00
-8.00
-12.00
-16.00
-20.00
SBNCH 1.500E+00 [EV_S]
SWITCHES: TFFFFTFFFF
-5.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
THETA -- RF PHASES 2. * THETA + 3.142 & 84. * THETA + -.000
(*10¹)

Figure 2

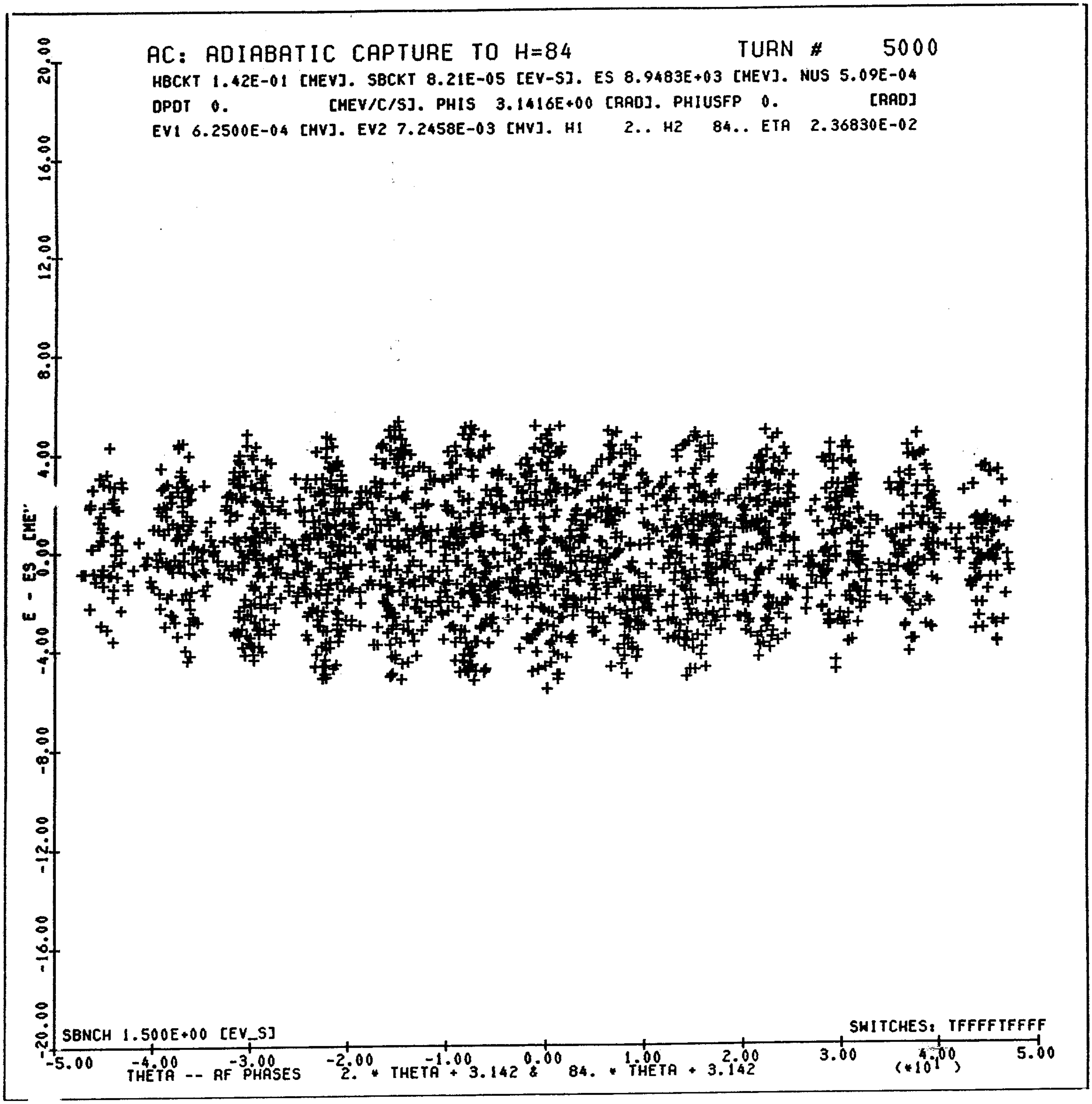
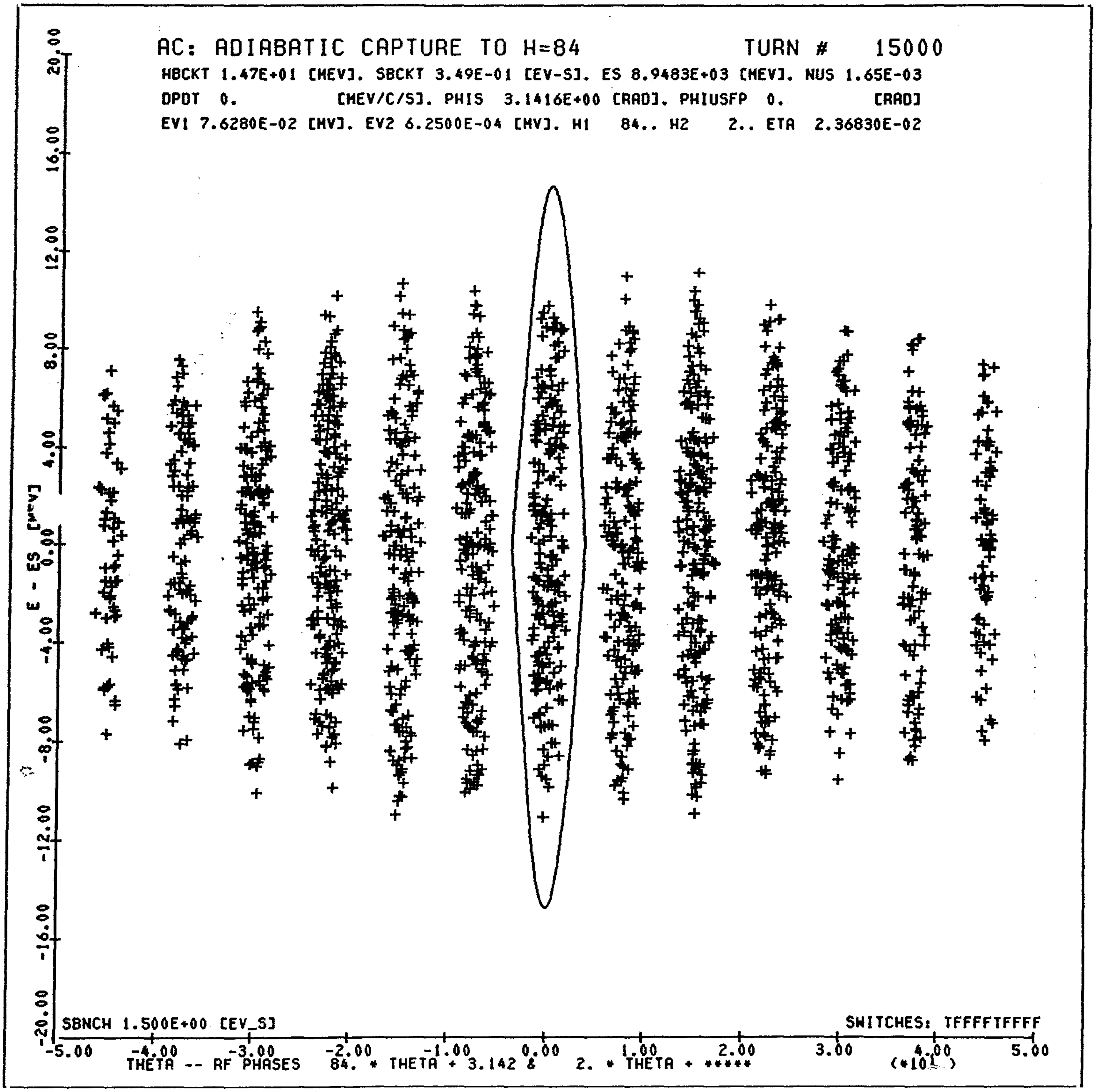
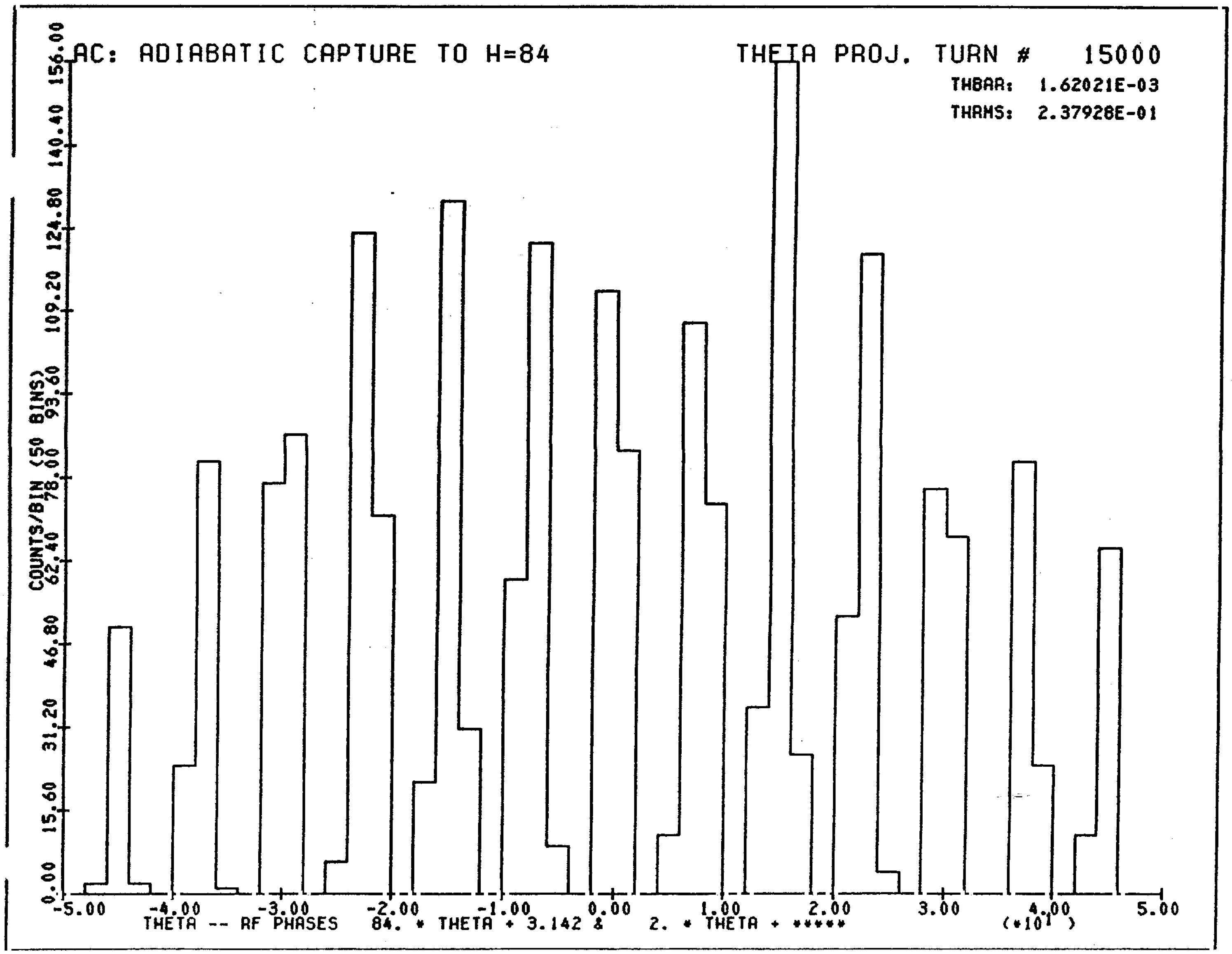

AC: ADIABATIC CAPTURE TO H=84
TURN # 5000
HBCKT 1.42E-01 [MEV]. SBCKT 8.21E-05 [EV-S]. ES 8.9483E+03 [MEV]. NUS 5.09E-04
DPDT 0. [MEV/C/S]. PHIS 3.1416E+00 [RAD]. PHIUSFP 0. [RAD]
EV1 6.2500E-04 [MV]. EV2 7.2458E-03 [MV]. H1 2.. H2 84.. ETA 2.36830E-02
20.00
16.00
12.00
8.00
4.00
0.00
-4.00
-8.00
-12.00
-16.00
-20.00
E - ES [ME'
SBNCH 1.500E+00 [EV_S]
SWITCHES: TFFFFTFFFF
-5.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
(*10^1)
THETA -- RF PHASES 2. * THETA + 3.142 & 84. * THETA + 3.142

Figure 3



AC: ADIABATIC CAPTURE TO H=84
TURN # 15000
HBCKT 1.47E+01 [MEV]. SBCKT 3.49E-01 [EV-S]. ES 8.9483E+03 [MEV]. NUS 1.65E-03
DPDT 0. [MEV/C/S]. PHIS 3.1416E+00 [RAD]. PHIUSFP 0. [RAD]
EV1 7.6280E-02 [MV]. EV2 6.2500E-04 [MV]. H1 84.. H2 2.. ETA 2.36830E-02
E - ES [MeV]
20.00
16.00
12.00
8.00
4.00
0.00
-4.00
-8.00
-12.00
-16.00
-20.00
SBNCH 1.500E+00 [EV_S]
SWITCHES: TFFFFTFFFF
-5.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
THETA -- RF PHASES 84. * THETA + 3.142 & 2. * THETA + *****
(*10^1)

Figure 4



AC: ADIABATIC CAPTURE TO H=84
THETA PROJ. TURN # 15000
THBAR: 1.62021E-03
THRMS: 2.37928E-01
COUNTS/BIN (50 BINS)
0.00
15.60
31.20
46.80
62.40
78.00
93.60
109.20
124.80
140.40
156.00
-5.00
-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
(*10¹)
THETA -- RF PHASES 84. * THETA + 3.142 & 2. * THETA + *****

Figure 5

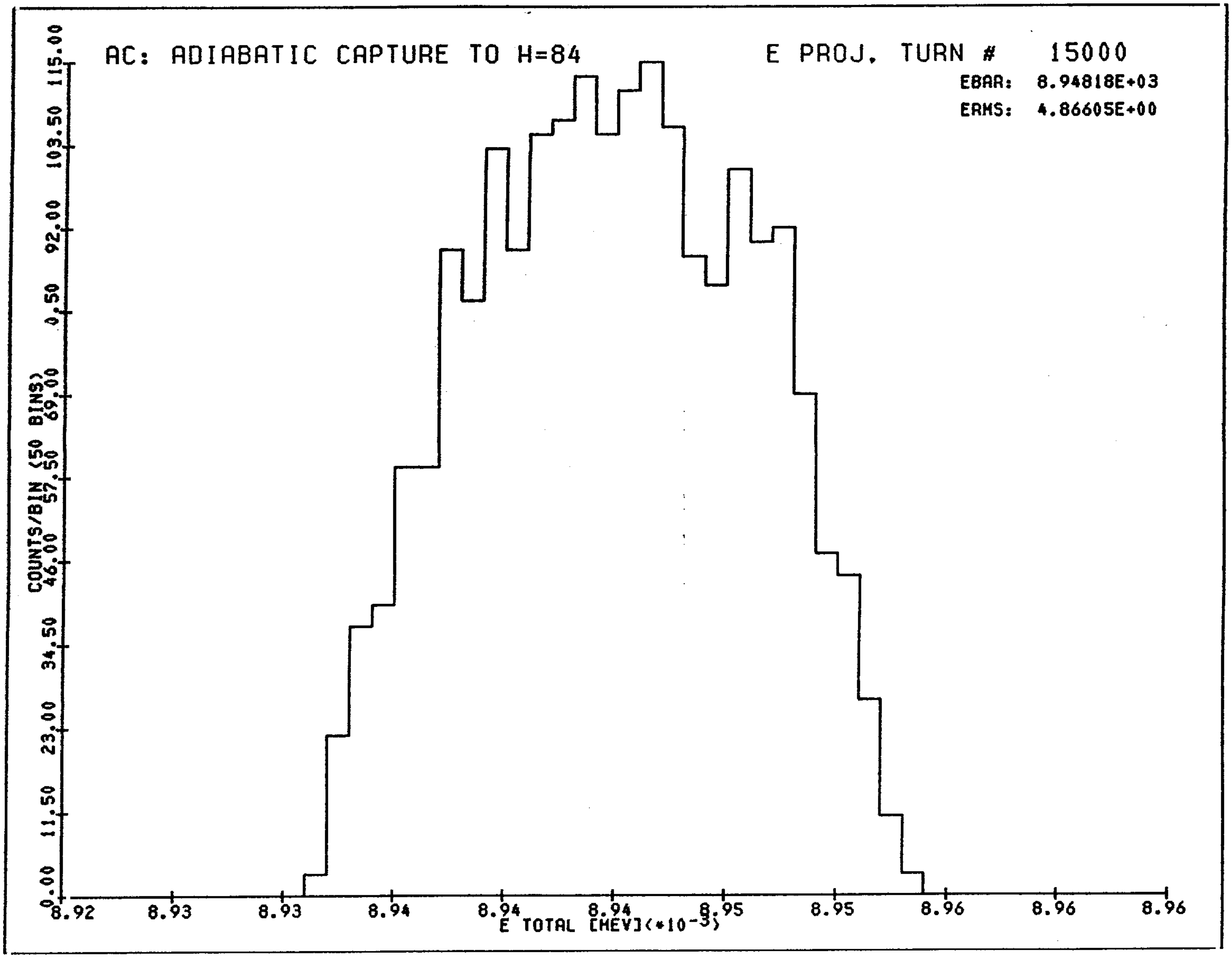
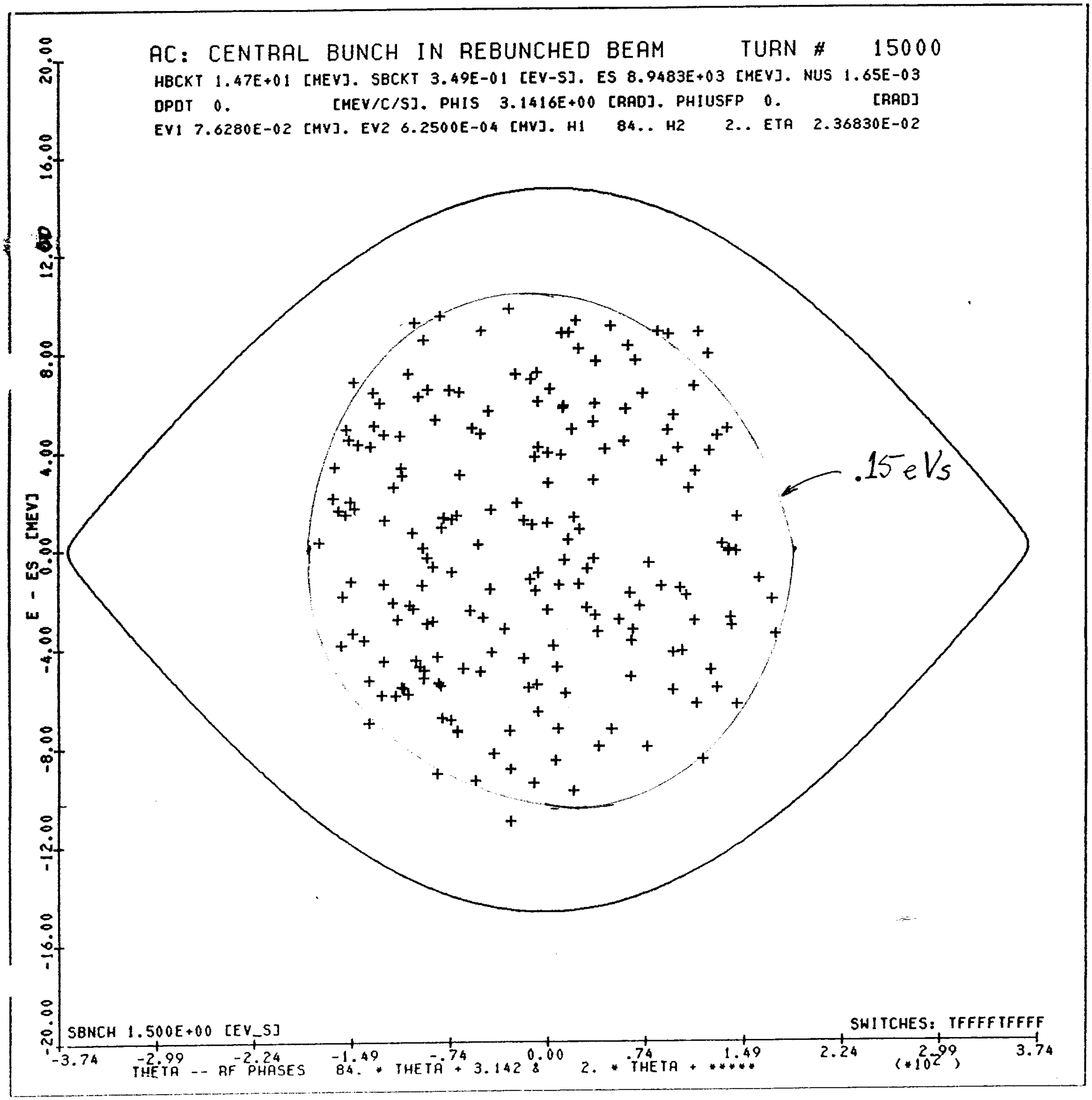

AC: ADIABATIC CAPTURE TO H=84
E PROJ. TURN # 15000
EBAR: 8.94818E+03
ERMS: 4.86605E+00
COUNTS/BIN (50 BINS)
0.00
11.50
23.00
34.50
46.00
57.50
69.00
0.50
92.00
103.50
115.00
8.92
8.93
8.93
8.94
8.94
8.94
8.95
8.95
8.96
8.96
8.96
E TOTAL [MEV](*10^-3)

Figure 6



AC: CENTRAL BUNCH IN REBUNCHED BEAM TURN # 15000
HBCKT 1.47E+01 [MEV]. SBCKT 3.49E-01 [EV-S]. ES 8.9483E+03 [MEV]. NUS 1.65E-03
DPDT 0. [MEV/C/S]. PHIS 3.1416E+00 [RAD]. PHIUSFP 0. [RAD]
EV1 7.6280E-02 [MV]. EV2 6.2500E-04 [MV]. H1 84.. H2 2.. ETA 2.36830E-02
.15 eVs
E - ES [MEV]
20.00
16.00
12.00
8.00
4.00
0.00
-4.00
-8.00
-12.00
-16.00
-20.00
SBNCH 1.500E+00 [EV_S]
SWITCHES: TFFFFTFFFF
-3.74
-2.99
-2.24
-1.49
-.74
0.00
.74
1.49
2.24
2.99
3.74
(*10^2)
THETA -- RF PHASES 84. * THETA + 3.142 & 2. * THETA + *****